SULZER LABORATORIES DIVISION

9610 Bellanca Avenue, Los Angeles, California 90045, AC 213 / 670-5544

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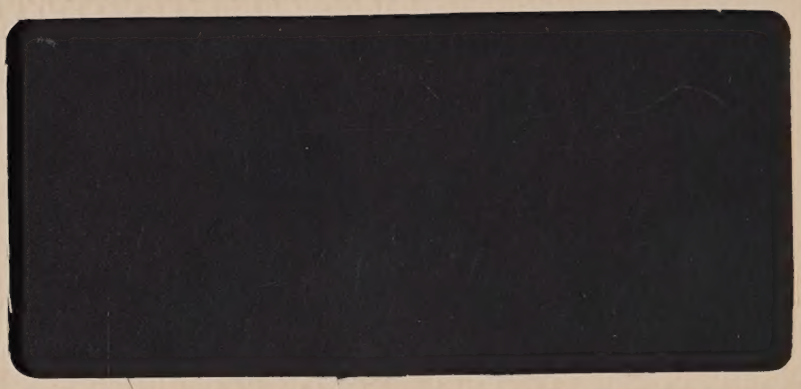

OPERATION AND SERVICE MANUAL

MODEL 1 LINEAR PHASE DETECTOR

SERIAL NO. 123

August, 1968

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TRACOR, Inc.

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WARRANTY

TRACOR, Inc. warrants each instrument it manufactures to be free from defects in material and workmanship. The obligation under this warranty is limited to repairing or replacing any instrument or part thereof that shall be returned to us by the original purchaser, transportation charges prepaid, when upon examination it is disclosed to our satisfaction to be defective. This warranty is effective for one year after delivery to the original purchaser. If the fault has been caused by misuse or abnormal conditions of operation, repair will be made at cost. In this case, an estimate will be submitted before work is started.

If any fault develops, notify TRACOR, Inc. and give full details, including model and serial numbers. You will then be notified as to the disposition of the defective instrument.

SULZER LABORATORIES DIVISION
9610 Bellanca Avenue
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TRACOR

A6-106-78

MODEL 1

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MODEL 1 LINEAR PHASE DETECTOR

DESCRIPTION

The Linear Phase Detector produces an output that is directly proportional to the phase difference between two sinusoidal inputs. The direct-current output is sufficient to drive a 1-milliampere-full-scale recorder with a resistance of 1600 ohms or less. The record produced is one of phase versus time, with full-scale deflection corresponding to 360 degrees.

The principal use of the phase detector is in comparing frequencies that are almost identical. If the two input frequencies are identical, the recorder will draw a straight line because there will be no gain or loss of phase with time. If there is a slight, but constant, frequency difference the record will be a sawtooth whose period is the time required for the loss or gain of 1 cycle at the input frequency. As an example, if the two inputs are at 1 MHz, and the frequency difference is 1×10^{-9}, one complete sawtooth will be produced every 1000 seconds. The slope of the sawtooth will indicate the frequency difference directly. The phase detector is also useful for measuring the phase characteristics of networks over a wide frequency range, since it is useful from 50 cycles to 1 MHz. Although the unit is relatively insensitive to input-voltage variations, the input should be held between 0.8 and 5 volts RMS. The input impedance is in excess of 500 ohms.

MODEL 1 LINEAR PHASE DETECTOR

SPECIFICATIONS

The Linear Phase Detector produced an output that is directly proportional to the phase difference between two sinusoidal or squarewave inputs. The principal use of the Detector is in the comparison of time outputs from two, 100 kHz clocks, the phase detector, and a suitable recorder. Full-scale deflection of the recorder will correspond to 360 degrees, or 10 microseconds. If the clocks remain at exactly the same frequency, the record of phase vs. time will be a straight line having zero slope. If there is a frequency difference, the time lost or gained can be read directly with a resolution of about 0.1 microsecond. The slope will indicate the frequency difference. If 10 times the resolution is desired, the phase detector can be operated at 1 MHz if that frequency is available from both clocks. Conversely, lower resolution could be obtained with a lower frequency.

Frequency standards can be compared with extremely high resolution by making use of the relation that $\Delta t = 8.64 \frac{\Delta f}{f} T + 4.32kT^2$, where Δt is the time lost or gained during T days, $\frac{\Delta f}{f}$ is the frequency offset in parts in 10^{10}, and k is the drift rate in parts in 10^{10} per day. If the time resolution of the phase detector plus recorder is 0.01 microsecond and T = 1 day, $k = 2.3 \times 10^{-13}$ per day. Thus, it is easy to detect drift rates as small as 1×10^{-13} per day.

Other specifications are as follows:

(1) Inputs: 2 20 volts peak-to-peak, sinewave or squarewave, 50 Hz to 1 MHz.

(2) Input impedance: Over 500 ohms.

(3) Output: 1 ma DC corresponding to full scale, to a load resistance of 2000 ohms or less.

SPECIFICATIONS (continued)

(4) Test provision: Zero and full-scale deflection can be produced or meter or recorder alignment.

(5) Size: $1\frac{3}{4}$" x 19" rack panel, 6" deep behind panel.

(6) Weight: $3\frac{1}{2}$" pounds.

(7) Access: Power cord at rear, signal inputs (BNC) and recorder outputs (dual binding posts and banana jacks [$\frac{3}{4}$" centers] at both front and rear).

(8) Power required: 105-125 volts 50-60 c/s, approximately 7.5 watts.

OPERATING INSTRUCTIONS

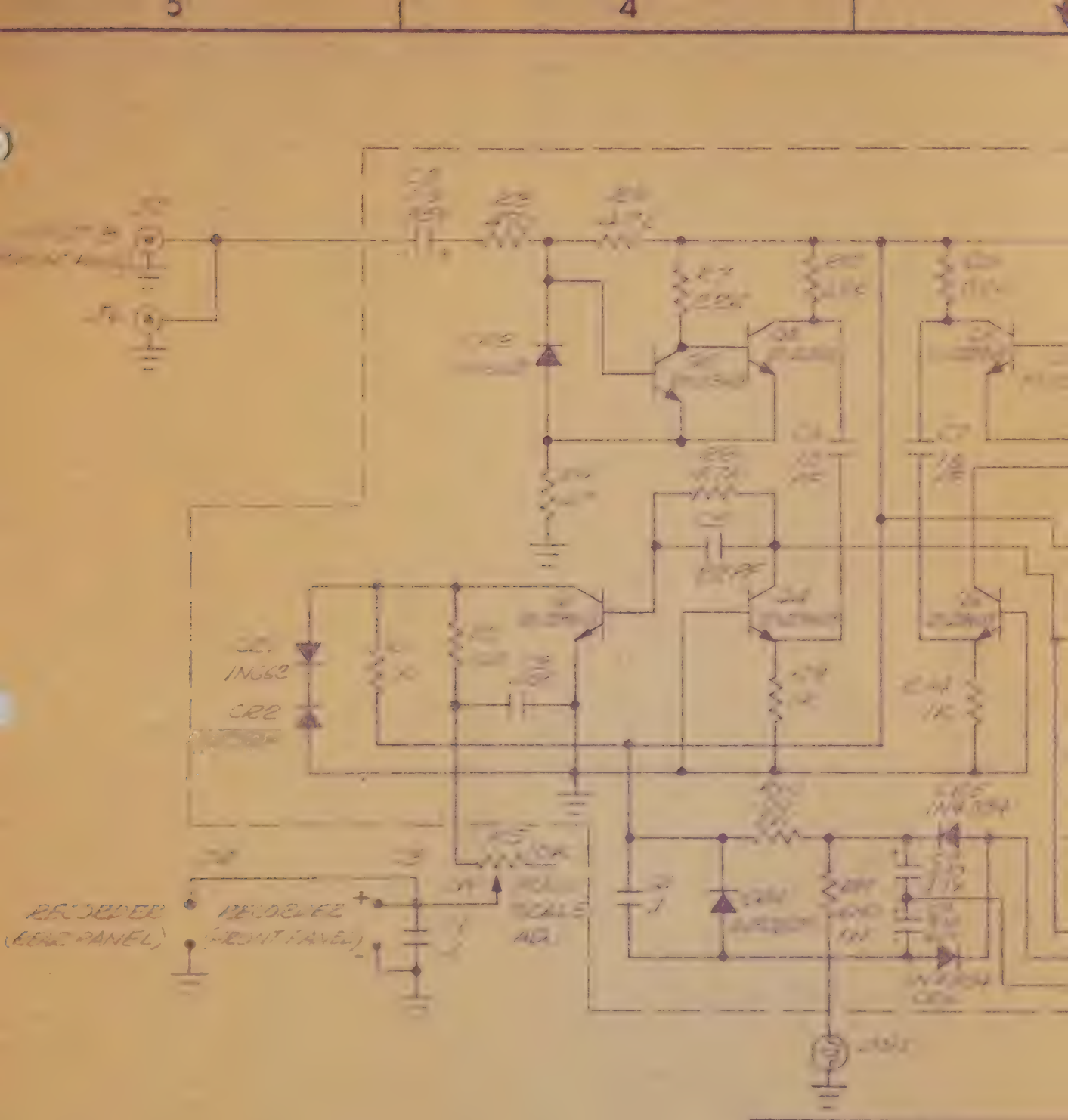
The equipment can be put into operation by connecting the necessary inputs, the power line and a recorder or meter. Identical input and output connections are available at the front and rear of the cabinet. Proper meter deflection can be checked by using the two red buttons that are adjacent to the front-panel recorder terminals. The indicator should be set to zero with the "ZERO" button pressed, and the screwdriver-adjusted control should be set for full-scale deflection with the "FULL SCALE" button pressed. The presence or absence of inputs will not affect these adjustments. The output current of the phase detector will increase with time if input B has a higher frequency than input A. In terms of phase, the output current will increase if the phase of input B is made to lead that of input A by an increasing amount.

CIRCUIT DESCRIPTION

Functioning of the phase detector can be understood with the air of the schematic diagram. Sinewave inputs A and B are shaped in two, separate regenerative clippers. The clippers consist of direct-coupled, emitter-coupled multivibrators that generate squarewaves whose zero crossings correspond closely to those of the input sinewaves. The squarewaves are differentiated by capacitors C6 and C7, and the resulting current pulses are amplified by Q4 and Q6, which conduct only when their emitters are driven negatively. Amplifiers Q4 and Q6 are used to trigger a high-speed bistable multivibrator or binary. One squarewave will trigger the binary to one state, and the other will trigger it back to the initial state. As a result, the collector voltage of either transistor in the binary will be a rectangular pulse whose duration is a function of the time difference or phase difference between the two inputs. The rectangular pulse from one of the transistors is amplified and clipped. The amplitude of the resulting waveform is standardized by breakdown diode CR2. The average current through R5 and the recorder or meter is directly proportioned to the duty cycle of the pulse derived from the binary. If the phase of one input changes uniformly with respect to that of the other, a sawtooth record will be obtained, as discussed above.

Because of the fact that, if the binary has just been triggered to one state it cannot immediately be triggered back to the other state, a portion of the record will be lost during the flyback interval of the sawtooth. The resulting ambiguity is approximately 0.05 microsecond, which means that about 10% of the record will appear as flyback when the inputs are a 1 MHz. At lower input frequencies a correspondingly smaller part of the record will be lost.

The power supply uses a voltage-doubler rectifier and a 20-volt breakdown-diode regulator.



1. ALL RESISTORS ARE 1/2W, 10%.

NEXT ASSY	USED ON
APPLICATION	

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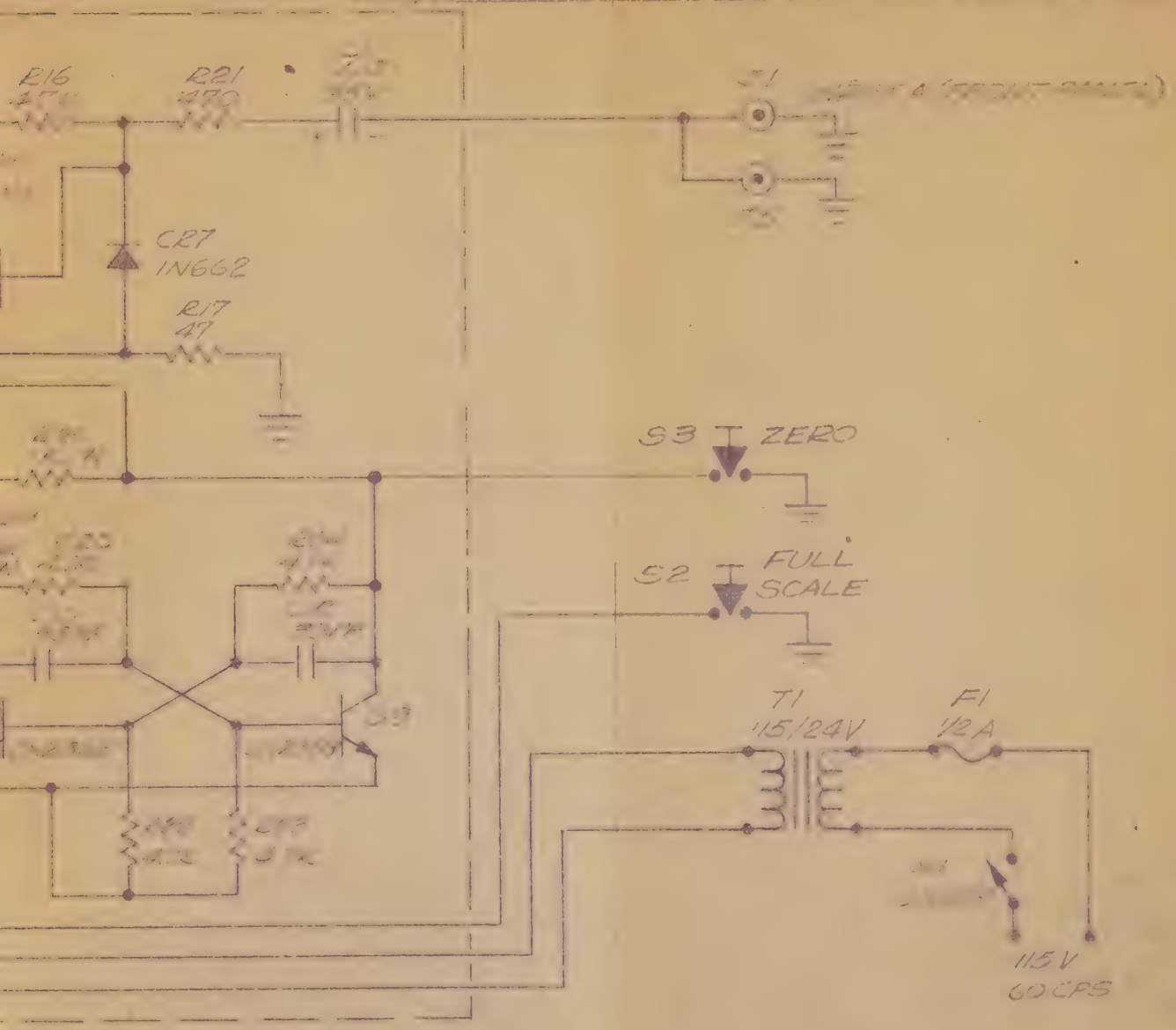
LTR	DESCRIPTION	DATE	APPROVED



QTY REQD	ITEM NO.	PART NUMBER	REFERENCE DESIGNATION	PART NAME / DESCRIPTION	MATERIAL OR MANUFACTURER	SPECIFICATION	VOLT AMPERE	ZONE

DO NOT SCALE DRAWINGS
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
DECIMALS ANGLES
XX = ± .02 ± 0° 30'
XXX = ± .010
FRACTIONS
± 1/32

MATERIAL:

CONTRACT NO.

DRAFTSMAN		
CHECKED		
APPROVED		
APPROVED		
APPROVED		

SULZER LABORATORIES
LOS ANGELES, CALIFORNIA
A DIVISION OF TRACOR INC.

TITLE

SIZE	CODE IDENT NO.	DRAWING NUMBER	REV
B	23732		

SCALE WEIGHT SHEET

PARTS LIST

MODEL 1 LINEAR PHASE DETECTOR

PART NO.	DESCRIPTION	REF. DESIG.	MANUFACTURER
Coml	Screw, Pan head, 6-32 x $\frac{1}{4}$ Lg. Cres		
Coml	Screw, Pan head, 6-32 x 5/16 Lg. Cres		
Coml	Washer, Flat, #6 Cres		
Coml	Washer, Splitlock #6 Cres		
Coml	Washer, Flat #8 Cres		
Coml	Washer, Splitlock #8 Cres		
Coml	Nut, Hex, 6-32 Cres		
Coml	Nut, Hex 8-32 Cres		
Coml	Screw, Self-Tap. Bind. Hd. #6 Type B(Z) $\frac{1}{4}$" Cres		

PARTS LIST

MODEL 1 LINEAR PHASE DETECTOR

PART NO.	DESCRIPTION	REF. DESIG.	MANUFACTURER
S-48724	Panel, Front		Sulzer
S-48730	Chassis		Sulzer
S-38731	Cover		Sulzer
S-48741 (P/L)	Component Board		Sulzer
1DP-2-104	Capacitor, .1μF	C1	Elmenco
327	Lamp, Miniature, 28V, white,	DS1	G.E.
312.500	Fuse, ½ Amp	F1	Littelfuse
UG-1094A/U	Connector, BNC	J1	Amphenol
UG-1094A/U	Connector, BNC	J2	Amphenol
269RB	Connector, Post	J3	H.H. Smith
269RB	Connector, Post	J4	H.H. Smith
CLU-1031	Resistor, Variable, 10K	R5	Ohmite
ST12-A	Switch, Toggle, SPST	S1	J.B.T.
30-1	Switch, Pushbutton	S2	Grayhill
30-1	Switch, Pushbutton	S3	Grayhill
S-18749	Transformer, Power, (T304)	T1	Sulzer
162-8430-1472-502	Lampholder,	XDS1	Dialco
342004	Fuseholder	XF1	Littelfuse
UG-1094/U	Connector, BNC	J5	Amphenol
UG-1094/U	Connector, BNC	J6	Amphenol
SR-5P-4	Bushing		Heyman
17236S	Cable, Power		Belden
1497	Solder Lug		H.H. Smith
1488-6	Solder Lug		H.H. Smith

COMPONENT BOARD ASSEMBLY (A1)

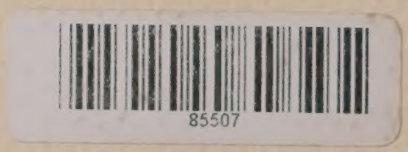
PART NO.	DESCRIPTION	REF. DESIG.	MANUFACTURER
S-38740	Printed Circuit Board		Sulzer
150D105X0035A2	Capacitor, 1μF	C2	Sprague
150D105X0035A2	Capacitor, 1μF	C11	Sprague
MC80V502AM	Capacitor, .005μF	C3	Aerovox
1DP-2-104	Capacitor, .1μF	C4	Elmenco
MC80V220AM	Capacitor, 22pf	C5	Aerovox
DM15C150J	Capacitor, 15pf	C6	Elmenco
DM15C150J	Capacitor, 15pf	C7	Elmenco
C437AR/G400	Capacitor, 400μF	C8	Amperex
C437AR/G400	Capacitor, 400μF	C9	Amperex
DM15C330J	Capacitor, 33pf	C10	Elmenco
CM15C330J	Capacitor, 33pf	C12	Elmenco
1N662	Diode	CR1	Texas Inst.
1N662	Diode	CR3	Texas Inst.
1N662	Diode	CR7	Texas Inst.
1N759A	Diode	CR2	Motorola
1N3027B	Diode	CR4	Motorola
1N4384	Diode	CR5	Texas Inst.
1N4384	Diode	CR6	Texas Inst.
2N2368	Transistor	Q1	Motorola
2N2368	Transistor	Q2	Motorola
2N2368	Transistor	Q3	Motorola
2N2368	Transistor	Q4	Motorola
2N2368	Transistor	Q5	Motorola

COMPONENT BOARD ASSEMBLY

PART NO.	DESCRIPTION	REF. DESIG.	MANUFACTURER
2N2368	Transistor	Q6	Motorola
2N2368	Transistor	Q7	Motorola
2N2368	Transistor	Q8	Motorola
2N2368	Transistor	Q9	Motorola
RC07GF102K	Resistor, 1K ¼W	R1	Mil-R-11
RC07GF102K	Resistor, 1K ¼ W	R9	Mil-R-11
RC07GF102K	Resistor, 1K ¼ W	R14	Mil-R-11
RC07GF103K	Resistor, 10K ¼ W	R2	Mil-R-11
RC07GF471K	Resistor, 470K ¼ W	R3	Mil-R-11
RC07GF471K	Resistor, 470K ¼ W	R21	Mil-R-11
RC07GF470K	Resistor, 47 ¼ W	R4	Mil-R-11
RC07GF470K	Resistor, 47 ¼ W	R17	Mil-R-11
RC07GF473K	Resistor, 47K ¼ W	R6	Mil-R-11
RC07GF473K	Resistor, 47K ¼ W	R16	Mil-R-11
RC07GF222K	Resistor, 2.2K ¼ W	R7	Mil-R-11
RC07GF222K	Resistor, 2.2K ¼ W	R12	Mil-R-11
RC07GF222K	Resistor, 2.2K ¼ W	R13	Mil-R-11
RC07GF222K	Resistor, 2.2K ¼ W	R15	Mil-R-11
RC07GF472K	Resistor, 4.7K ¼ W	R8	Mil-R-11
RC07GF472K	Resistor, 4.7K ¼ W	R20	Mil-R-11
RC07GF472K	Resistor, 4.7K ¼ W	R22	Mil-R-11
RC07GF472K	Resistor, 4.7K ¼ W	R23	Mil-R-11
RC07GF472K	Resistor, 4.7K ¼ W	R24	Mil-R-11

COMPONENT BOARD ASSEMBLY (A1)

PART NO.	DESCRIPTION	REF. DESIG.	MANUFACTURER
RC42GF101K	Resistor, 100 2W	R10	Mil-R-11
Series 99 #4116	Resistor, 680 1½ W	R11	Ohmite
Series 99 #4123	Resistor, 1K 1½ W	R18	Ohmite
Series 99 #4123	Resistor, 1K 1½ W	R19	Ohmite
100-200-2-9	Clip		Atlee
100-200-5-19	Clip		Atlee
Coml	Screw, Pan Head, 2-56 x ¼ Lg. Cres		
Coml	Washer, Flat #2 Cres		
Coml	Washer, Splitlock #2 Cres		
Coml	Nut, Hex, 2-56 Cres		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